Appl. No. 09/822,586
Amendment dated December 13, 2005
Reply to Final Office Action of October 17, 2005

Amendments to Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims

Claims 1-28 (cancelled).

Claim 29 (currently amended): A method for blind registration of first and second images out of registration, the method comprising the steps of:

(a) applying nonlinear pre-filtering and thresholding to the first and second images, thereby enhancing cross-spectral correlation between the first and second images, wherein applying the nonlinear pre-filtering further comprises applying an edge enhancement filter to make edges in the first and second images more prominent; and

(b) registering the first and second images by evaluating normalized correlation between the first and second images as a function of relative image position, where the normalized correlation is expressed as vector correlations computed in the Fourier domain.

Claim 30 (previously presented): The method of claim 29 wherein the normalized correlation is expressed as:

$$C(x,y)_i = \frac{(x \odot \tilde{y})_i - \frac{1}{M}(x \odot m)_i \left(\sum_{k=0}^{M-1} y_k \right)}{\sqrt{\left((x^{(2)} \odot m)_i - \frac{1}{M}(x \odot m)_i^2 \right) \left(\sum_{k=0}^{M-1} y_k^2 - \frac{1}{M} \left(\sum_{k=0}^{M-1} y_k \right)^2 \right)}}$$

where x is the first image expressed as an N-vector image, y is an M-vector pattern drawn from the second image, $\tilde{y}$ is the y vector extended to length N, and m is a mask vector whose first M elements are 1 and whose last N − M elements are 0.

Claim 31 (previously presented): The method of claim 29 further comprising the step of reducing resolution of the first and second images prior to registering the first and second images.

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Claim 32 (previously presented): The method of claim 31 wherein the resolution of the first and second images is reduced by partitioned the first and second images into blocks of pixels, each block of pixels replaced by a sum of pixel values in the block.

Claim 33 (previously presented): The method of claim 31 further comprising a step of blurring the first and second images prior to reducing resolution of the first and second images, where the images are blurred with a filter that thickens each pixel in an array that extends from a central pixel.

Claim 34 (previously presented): The method of claim 31 wherein the first and second images are registered at a low resolution and the resolution is subsequently refined to obtain higher precision.

Claim 35 (cancelled).

Claim 36 (currently amended): The method of claim 35 29 wherein the edge enhancement filter is direction independent to reduce computational costs.

Claim 37 (previously presented): The method of claim 29 wherein applying thresholding to the first and second images further comprises computing a histogram of pixel intensities and setting a threshold for which a percentage are over the threshold.

Claim 38 (previously presented): The method of claim 37 wherein the threshold is 70 to 80 percent of pixels in the images.

Claim 39 (currently amended): A program storage device readable by machine, tangibly embodying a program of instructions executable by machine to perform method steps for blind registration of first and second images out of registration, the method comprising the steps of:

(a) applying nonlinear pre-filtering and thresholding to the first and second images, thereby enhancing cross-spectral correlation between the first and second images, wherein

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applying the nonlinear pre-filtering further comprises applying an edge enhancement filter to make edges in the first and second images more prominent; and

(b) registering the first and second images by evaluating normalized correlation between the first and second images as a function of relative image position, where the normalized correlation is expressed as vector correlations computed in the Fourier domain.

Claim 40 (previously presented): The program storage device of claim 39 wherein the normalized correlation is expressed as:

$$C(x,y)_i = \frac{(x \odot \tilde{y})_i - \frac{1}{M}(x \odot m)_i \left(\sum_{k=0}^{M-1} y_k\right)}{\sqrt{\left((x^{(2)} \odot m)_i - \frac{1}{M}(x \odot m)_i^2\right)\left(\sum_{k=0}^{M-1} y_k^2 - \frac{1}{M}\left(\sum_{k=0}^{M-1} y_k\right)^2\right)}}$$

where x is the first image expressed as an N-vector image, y is an M-vector pattern drawn from the second image, $\tilde{y}$ is the y vector extended to length N, and m is a mask vector whose first M elements are 1 and whose last N − M elements are 0.

Claim 41 (previously presented): The program storage device of claim 39 further comprising the step of reducing resolution of the first and second images prior to registering the first and second images.

Claim 42 (previously presented): The program storage device of claim 41 wherein the resolution of the first and second images is reduced by partitioned the first and second images into blocks of pixels, each block of pixels replaced by a sum of pixel values in the block.

Claim 43 (previously presented): The program storage device of claim 41 further comprising a step of blurring the first and second images prior to reducing resolution of the first and second images, where the images are blurred with a filter that thickens each pixel in an array that extends from a central pixel.

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Claim 44 (previously presented): The program storage device of claim 41 wherein the first and second images are registered at a low resolution and the resolution is subsequently refined to obtain higher precision.

Claim 45 (cancelled).

Claim 46 (currently amended): The program storage device of claim 45 39 wherein the edge enhancement filter is direction independent to reduce computational costs.

Claim 47 (previously presented): The program storage device of claim 39 wherein applying thresholding to the first and second images further comprises computing a histogram of pixel intensities and setting a threshold for which a percentage are over the threshold.

Claim 48 (previously presented): The program storage device of claim 47 wherein the threshold is 70 to 80 percent of pixels in the images.

Claim 49 (currently amended): A computer program product embodied in a computer-readable medium for implementing blind registration of first and second images out of registration, the computer program product comprising:

(a) computer readable code means for applying nonlinear pre-filtering and thresholding to the first and second images, thereby enhancing cross-spectral correlation between the first and second images, wherein applying the nonlinear pre-filtering further comprises applying an edge enhancement filter to make edges in the first and second images more prominent; and

(b) computer readable code means for registering the first and second images by evaluating normalized correlation between the first and second images as a function of relative image position, where the normalized correlation is expressed as vector correlations computed in the Fourier domain.

Claim 50 (previously presented): The computer program product of claim 49 wherein the normalized correlation is expressed as:

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$$C(x,y)_i = \frac{(x \odot \bar{y})_i - \frac{1}{M}(x \odot m)_i \left(\sum_{k=0}^{M-1} y_k\right)}{\sqrt{\left((x^{(2)} \odot m)_i - \frac{1}{M}(x \odot m)_i^2\right)\left(\sum_{k=0}^{M-1} y_k^2 - \frac{1}{M}\left(\sum_{k=0}^{M-1} y_k\right)^2\right)}}$$

where x is the first image expressed as an N-vector image, y is an M-vector pattern drawn from the second image, ȳ is the y vector extended to length N, and m is a mask vector whose first M elements are 1 and whose last N – M elements are 0.

Claim 51 (previously presented): The computer program product of claim 49 further comprising computer readable code means for reducing resolution of the first and second images prior to registering the first and second images.

Claim 52 (previously presented): The computer program product of claim 51 wherein the resolution of the first and second images is reduced by partitioned the first and second images into blocks of pixels, each block of pixels replaced by a sum of pixel values in the block.

Claim 53 (previously presented): The computer program product of claim 51 further comprising computer readable code means for blurring the first and second images prior to reducing resolution of the first and second images, where the images are blurred with a filter that thickens each pixel in an array that extends from a central pixel.

Claim 54 (previously presented): The computer program product of claim 51 wherein the first and second images are registered at a low resolution and the resolution is subsequently refined to obtain higher precision.

Claim 55 (cancelled).

Claim 56 (previously presented): The computer program product of claim 49 wherein applying thresholding to the first and second images further comprises computing a histogram of pixel intensities and setting a threshold for which a percentage are over the threshold and wherein the threshold is 70 to 80 percent of pixels in the images.